Update: Arsenic

By Kelly A. Reynolds, Ph.D.

Arsenic is a poisonous agent found in nature at low levels and which makes its way to source waters via weathering of rocks and erosion. Arsenic in plants and animals (i.e. fish and seafood) combines with carbon and hydrogen to form less toxic organic compounds relative to the inorganic arsenic compounds generally associated with contaminated water. Inorganic arsenic compounds form when arsenic combines with oxygen, chlorine and sulfur.

Arsenic is considered a silent pollutant since there's generally no smell or taste associated with its presence. Furthermore, because many of these symptoms are indicative of a number of other illnesses, arsenic poisoning may easily go undetected.

More serious health effects from arsenic exposure include skin damage, circulatory system problems and an increased cancer risk, especially of the skin, bladder and lungs. Early warning signs may include stomach pain, nausea, vomiting, diarrhea and numbness in extremities. Exposures may be through food, especially fish and seafood, or drinking water.

Certain areas of the United States contain mineral deposits with high levels of arsenic that can leach into drinking water sources when groundwater flows through these deposits. The effect of arsenic exposure on any given individual depends on a number of factors including the ingested dose, duration of exposure, form of the arsenic compound and the immunological status of the person exposed—where age and general health play key roles.

Environmental sources

Although arsenic occurs naturally in mineral deposits throughout the world, many industrial applications contribute to these indigenous sources, including discharge from semiconductor manufacturing, petroleum refining and glass manufacturing, as well as products used as wood preservatives, animal feed additives, herbicides, and lead- or copper-based alloys.

Although arsenic use in agriculture declined in 1994 following a negotiated agreement with the U.S. Environmental Protection Agency (USEPA) limiting the use of arsenic acid desiccant production for cotton crops, demand for the compound remained unchanged due to increased demands for preserved wood. Thus, arsenic demand is closely tied to the economics of the home construction market, currently a booming business in the United States.

Regulatory issues

The current federal maximum contaminant level (MCL)—the maximum permissible level of arsenic in water which is delivered to any user of a public water system—was set in 1975 based on the 1943 standard set by the U.S. Public Health Service of 50 mg/L (micrograms per liter), or 50 parts per billion (ppb). MCLs are enforceable standards that must be maintained by public water suppliers.

Generally, health and water industry experts agree that an MCL of 50 ppb for arsenic does not adequately protect the public from adverse effects of the contaminant. A recent National Academy of Sciences report said the standard should be lowered but stopped short of recommending the USEPA adopt the World Health Organization limit of 10 ppb. Currently, for arsenic, there's no U.S. maximum contaminant level goal (MCLG)—the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health of persons would occur—since MCLGs were not established prior to the 1986 Amendments to the Safe Drinking Water Act.

MCLGs are non-enforceable public health goals. Arsenic, however, is one of 83 specific contaminants for which the USEPA is required to set an MCLG and a National Primary Drinking Water Regulation (NPDWR). Based on risk management components such as treatment technologies, occurrence assessment and cost / benefit analysis, the MCL is set as close as possible to the health goal, or MCLG, as is feasible. Therefore, proposed changes in the MCL of 50 mg/L range from 2-to-20 mg/L, which would yield an acceptable cancer risk of 1 in 10,000 over a lifetime.

Who's at risk?

Recently, the Association of California Water Agencies (ACWA) completed a survey of low-level arsenic occurrence in surface and groundwater in California. The survey is the first of a two-part study aimed at determining the impact on California water consumers of a revised drinking water regulation for arsenic. The ACWA is the largest statewide coalition of public water agencies in the United States, with 417 public agency members serving more than 90 percent of the state's water. Association concerns include how revised drinking water regulations for arsenic would effect the cost and available resources of water in the state.

Within this study, 1,500 water samples were collected over a 12-month period, from 1993-to-1994, via 180 agencies in 27 counties. The median value of arsenic found in the total samples was 2 mg/L, with only one source having a level above the current standard. Half of the surface water and 65 percent of the ground water had detectable levels of arsenic present. Depending on the new MCL standard level, many previously compliant utilities could now be out of regulatory compliance. Many U.S. utilities are recognizing the cost of compliance to a lower MCL is prohibitive and are fighting the regulatory change.

Another study sponsored by the Water Industry Technical Action Fund (WITAF) surveyed surface and groundwater arsenic occurrence levels nationwide to determine the rate of non-compliance to lowered standards. The study found distinct regional variances in arsenic occurrence. The East Coast and Southeast regions of the U.S. had low-level arsenic occurrence in both ground and surface water; including the Midwest, New England and Mid-Atlantic regions which had levels less than 5 mg/L. Surface water sources in the south central and north central U.S. and West had substantially higher proportions of elevated arsenic occurrence compared with the rest of the nation. Data is also available for some groundwater supplies where arsenic concentrations less than 5 mg/L were consistently found in the central Midwest, north central and south central U.S. and West.[1]

Based on USEPA-required monitoring data from domestic water utilities, six water systems—serving approximately 9,757 persons—reported MCL violations of arsenic between 1994 and 1995. If the MCL was lowered to 2 mg/L, the USEPA estimates that approximately 25 percent of all community water suppliers (11,550-to-11,890 systems) would fail compliance. Between 6 and 17 percent (2,775-to-7,870) are projected to violate a standard of 5 mg/L. And 1-to-3 percent (510-to-1,360) would fail to meet an arsenic standard of 20 mg/L.

In addition, public water utilities are required to monitor and control for arsenic to the MCL level; however, 16 percent of the U.S. population is served by private groundwater systems and may not be cognizant of the need for arsenic monitoring and control. Private well owners should contact public health agencies in their area and, if necessary, a test laboratory to determine if arsenic is a problem in their source water. Laboratory contracted testing may be easily performed at a cost of approximately $25-to-35 per analysis.[2]

Compliance costs

According to a recent USEPA report to Congress, depending on how arsenic is regulated, the estimated financial need for installation, upgrade or infrastructure replacement to comply with new arsenic standards ranges from $278.9 million to $7.126 billion.[3]

In the 1996 Amendments to the Safe Drinking Water Act (SDWA), Congress directed USEPA to expand arsenic health effects research and propose a new arsenic regulation by Jan. 1, 2000, with final regulation to occur by Jan. 1, 2001. Congress authorized $2.5 million per year, from 1997-to-2000, for the studies. The USEPA is currently funding research to evaluate the health effects from arsenic exposures in drinking water. One such study is being conducted in West Bengal, India, where a large population is exposed to drinking water containing arsenic. This research is due to be completed in the Fall of 2000 and aims to establish a dose-response relationship for malignant skin tumors and other skin ailments associated with ingestion of inorganic arsenic.

While long term research will not be completed prior to the statutory deadline, the USEPA is committed to a reevaluation every six years or less of all its primary drinking water regulations.

Conclusion

A variety of water treatment options are effective for arsenic removal including activated alumina, ion exchange, lime softening, oxidation combined with reverse osmosis (RO), ion exchange, alum or iron coagulation with filtration, distillation and nanofiltration.

While many treatment technologies are available and effective for arsenic removal, the choice of treatment depends on the scale, cost requirements and water quality parameters. Point of use/ point of entry (POU/POE) systems can be effective and affordable treatment options for individuals in lieu of the changing standard and feasible compliance options for small systems in meeting a new arsenic MCL.

References

1. Frey, M.M. and M.A. Edwards, "Surveying arsenic occurrence," *Journal AWWA*, 89(2): 105-117, 1997.

2. Shank-Givens, H.L., "Arsenic drinking water regulation background information," USEPA, Office of Ground Water and Drinking Water, Washington, D.C., 1994.

3. USEPA, "Drinking water infrastructure needs survey: First report to Congress," Office of Water, USEPA 812-R-97-001, Washington, D.C. (in January 1995 dollars) 1997.

4. U.S. Bureau of Mines, *Arsenic, Mineral Commodities Summaries*, 1994.

About the author

♦*Dr. Kelly A. Reynolds is a research scientist at the University of Arizona with a focus on the development of methods for detecting human pathogens in drinking water. She is also a member of the WC&P Technical Review Committee.*

Sources for more arsenic information:

Association of California Water Agencies home page: www.acwanet.com

U.S. Environmental Protection Agency Office of Ground Water and Drinking Water:

www.epa.gov/OGWDW/ars/arsenic.html

West Bengal, India & Bangladesh Arsenic Crisis Info Centre: http://bicn.com/acic/